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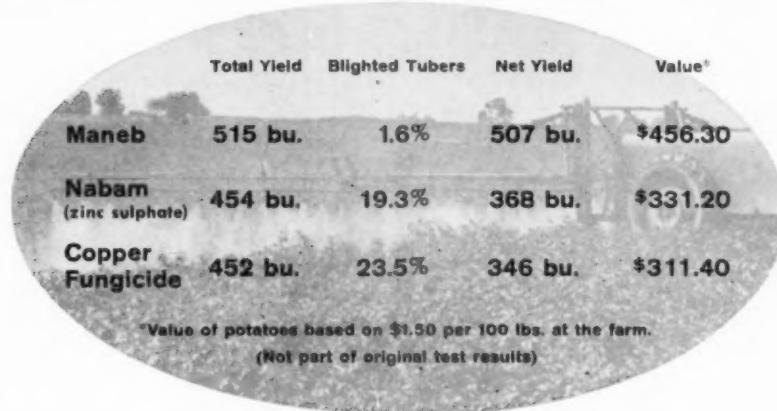
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EFFECT OF SULFATE AND CHLORIDE SOURCES AND RATES OF POTASSIUM ON POTATO GROWTH AND TUBER QUALITY¹

GERALD E. WILCOX²

INTRODUCTION

Potato production in Southwestern Indiana was recently initiated to provide a source of potatoes for Midwest chippers during late July and early August. The potatoes are produced specifically for processors and must be of a quality acceptable to the processing trade. Since fertilization is one factor that the grower can control, it is imperative that he has information as to the effect of fertilizer materials and rates on potato growth and quality. Muriate of potash was reported to lower the dry-matter content of potatoes in the Red River Valley (1). However, Murphy and Goven (5) reported on research work in Maine that from thirteen field experiments over the period of 1952-1958 no significant difference in specific gravity of tubers was obtained due to use of potassium chloride or potassium sulfate at 120 or 240 pounds K₂O per acre.

This investigation was initiated to study the effect of broadcast applications of chloride and sulfate sources and rates of potassium on tuber quality and yield.

MATERIALS AND METHODS

This experiment was initiated in the spring of 1959 on the Paul Klein farm near Vincennes, Indiana on a Genesee sandy loam, an alluvial terrace soil underlain with gravel. Eight treatments, 0, 75, 150 and 225 pounds per acre K₂O applied either as the SO₄⁼ or the Cl⁻ form were replicated four times in a randomized block design. To intensify the anion effect, the nitrogen was applied as ammonium sulfate with the potassium sulfate treatments and as ammonium chloride with the potassium chloride treatments. Sixty-six pounds per acre of nitrogen were applied with the basic treatment. The N and K fertilizer was broadcast and disked into the soil just before planting. In 1959, a 32-128-0 fertilizer treatment was applied in the band and in 1960 a 44-192-0 fertilizer treatment was applied in the band at planting time.

Kennebec potatoes were planted 9 inches apart in the row on March 24, 1959 and April 6, 1960. The individual plots were 12 feet wide and 36 feet long. Four rows were planted on each plot and 26 feet of the two center rows were harvested for yield and tuber sampling.

The initial soil test values averaged 70 pounds per acre for phosphorus and 161 pounds per acre for potassium as determined by the Purdue Soil Testing Laboratory. In the laboratory available phosphorus and potassium are extracted by shaking 5 g of soil with 15 ml of 0.75 N HCl on a shaker for 2 minutes. The values are expressed in terms of pounds P₂O₅ and K₂O per 2 million pounds soil. The soil was pH 6.1.

¹Accepted for publication October 14, 1960. Journal Paper No. 1670. Purdue University Agricultural Experiment Station, Lafayette, Indiana.

²Assistant Professor of Agronomy and Horticulture.

Plant samples were collected as recently matured leaves on ten plants in the two center rows of each plot. In 1959, the sample date was May 26 at the bud stage. In 1960, samples were collected June 1 at bud stage when tubers were just beginning to set and June 15 when the tubers were developing rapidly. The samples were dried at 70 C in a forced air oven and ground to 20 mesh fineness. The tissue was analyzed for P, Ca, Mg and K according to the methods described by Jackson (2).

The potatoes were harvested on July 26, 1959 and July 25, 1960. Four tubers from each treatment were chipped two days after harvest at the Chesty Potato Chip factory in Terre Haute, Indiana. The vat temperature was 325 F. The chip samples were prepared for color determination by grinding in a Waring blender 20 g chips and 100 ml H₂O. The slurry was poured into a cell and read on a Hunter color-difference meter that was standardized against a white standard, L = 85.3.

RESULTS

Leaf analyses. In 1959, growing conditions were favorable up to the prebloom stage on May 26 at which time the topmost mature leaf samples were collected. No visual differences were apparent between treatments. However, chemical analysis of the leaves, showed that there was a treatment effect on their composition (Table 1). There were no significant differences in P composition amongst treatments. As the rate of K application was increased, its concentration in the leaf tissue was increased, but there was no differential effect due to associated anion. Ca and Mg in the leaf decreased as the K rate of application increased. The amount of Ca was higher and Mg tended to be higher for the Cl treatments than for the SO₄ treatments.

In 1960, temperature, prior to prebloom stage was lower than in 1959. However, the leaves sampled at prebloom stage showed nearly the same effects as the previous year (Table 2). Another sampling was made on June 15 at which time the tubers were developing rapidly. The tissue at this time reflected the treatment effects more vividly than at the earlier sampling. The P content in the leaf was reduced by the highest K treatments with no differential effect due to source of K. Severe potassium deficiency symptoms had developed on the 0 potassium treatments and the vine growth was much less than that of the higher K treatments. The vine growth on the KCl treatments was very rank and the leaf color light green as compared to a dark green foliage on the SO₄ treatments. Fewer blossoms were visible on the KCl treated plots than on the K₂SO₄ treated plots which indicated the possibility that for comparative treatments, the potatoes were not at the same stage of maturity.

The K content in the tissue was increased by increasing K additions to the soil while the Ca and Mg in the tissue was decreased. For K, there was no effect due to source, but for Ca and Mg again as in 1959 the levels were higher in tissue from the Cl treatments. At the highest K level, the effect of K concentration overshadowed the effect of source so that the composition of Ca and Mg was the same from the two sources.

TABLE 1. *Chemical composition at bud stage of growth of sulfate and chloride treated potatoes. 1959.*

Treatment ¹			Composition			
Rate K ₂ O Application	Anion Source	Rate Lbs/A	P	K	Ca	Mg
Lbs/A		Lbs/A		%		
0	SO ₄	230	.22	3.08	1.48	.46
75		322	.20	3.65	1.20	.42
150		414	.21	4.02	1.02	.31
225		506	.22	4.43	1.04	.35
0	Cl ⁻	170	.24	2.57	1.76	.60
75		220	.20	3.61	1.49	.45
150		270	.19	4.25	1.28	.43
225		320	.20	4.47	1.41	.42
LSD 5% Level			NS	0.99	0.26	.10

¹The SO₄ treatment included 66 pounds of N as (NH₄)₂SO₄ and the Cl⁻ treatments included 66 pounds of N as NH₄Cl broadcast preplant with the potassium treatments. All plots received 32-128-0 in bands at planting.

TABLE 2. *Chemical composition of topmost mature potato leaf of bud stage of growth. 1960.*

Treatment ¹			Composition					
Rate K ₂ O Application	Anion Source	Rate Lbs/A	P 6/1	K 6/15	P 6/1	K 6/15	Ca 6/1	Mg 6/15
Lbs/A		Lbs/A			Per cent			
0	SO ₄	230	.35	.22	2.25	1.6	1.05	.44
75		322	.30	.20	2.70	2.5	1.02	.38
150		414	.32	.19	3.55	2.1	0.78	.36
225		506	.33	.18	4.23	2.6	0.88	.38
0	Cl ⁻	170	.31	.24	2.02	1.9	1.37	.51
75		220	.32	.22	2.80	2.2	1.13	.45
150		270	.31	.18	2.92	2.5	1.03	.38
225		320	.31	.19	4.28	3.3	1.00	.37
LSD 5% Level			NS	.03	0.92	0.48	0.28	0.33
							0.06	0.12

¹Same as table 1 except all plots received 44-192-0 in bands at planting.

Tubers. The yield, specific gravity and chip color of potatoes are presented in Table 3. In 1959 the amount of rainfall during June and July was low and the irrigation was not adequate for optimum moisture conditions. Consequently, no significant differences were obtained in yield or specific gravity. The chips from the chloride treated plots were generally lighter in color than those from the sulfate treatments. The highest K level of the SO₄ series produced a lighter chip than the lower K levels of fertilization.

In 1960, yields were increased by the addition of K fertilizer. For the sulfate series, the increase was linear up to the 150 pound rate after which the rate of increase fell off sharply. Nearly maximum yields

TABLE 3. *Potato yield, specific gravity and chip color from various fertilizer treatments. Paul Klein farm, 1959, 1960.*

Treatment ¹		Yield		Specific gravity		Chip color White x L=85.3	
Rate K ₂ O applied	Anion	1959	1960	1959	1960	1959	1960
Lbs./A		CWT./A				L	
0	SO ₄	240	248	1.093	1.078	56.6	53.8
75		217	276	92	77	57.2	64.6
150		240	312	91	74	59.3	61.2
225		228	324	88	76	62.9	66.2
0	Cl	210	243	87	70	60.4	50.4
75		238	285	89	70	63.3	59.3
150		248	285	88	71	61.1	66.2
225		219	296	89	73	63.3	68.0
LSD							
5% Level		NS	39.3	NS			
10% Level			32.6		3.1		

¹Same as table 1 & 2.

were obtained after the first increment of potassium was applied as KCl with a slight, but not significant, increase occurring at the highest rate. The specific gravity of the potatoes from the sulfate treatments were higher than those from the chloride treatments. The potato chips from the zero K treatments were very dark in color. As the potassium rate was increased the chips were lighter in color. The chips from the sulfate treatments had a prominent dark brown vascular ring. The 225 KCl treatment produced the most desirable chips of uniform light tan color (Fig. 1).

DISCUSSION

The associated anion with the broadcast fertilizer can affect equilibrium conditions in the soil solution that cause seedling composition to be different. According to unpublished data of the author, the chloride source of fertilizer broadcast preplant increases the concentration of the calcium and magnesium in the soil solution compared with the sulfate source. This could very well be the cause of the different composition found in the leaf tissue. Although test for chloride in the tissue on July 6 was negative the effect on the seedling carries through its entire growth cycles. Kalinkevich and Aleksandrovshaya (3) report that KCl placed with the tuber seedpiece retarded CO₂ production, conversion of starch into sugar and utilization of stored nitrogenous substances by young plants. Even with broadcast KCl just before planting, this mechanism could also be occurring to affect the vigor of the seedling. To reduce the possibility of this, the KCl should be applied a sufficient period before planting to allow the excess Cl to leach from the soil. In Holland, a common practice is to apply the KCl in the fall.

The potatoes were checked at two week intervals with the quick tissue test procedure (4) for potassium. The plant sap tested 4,000-5,000 ppm

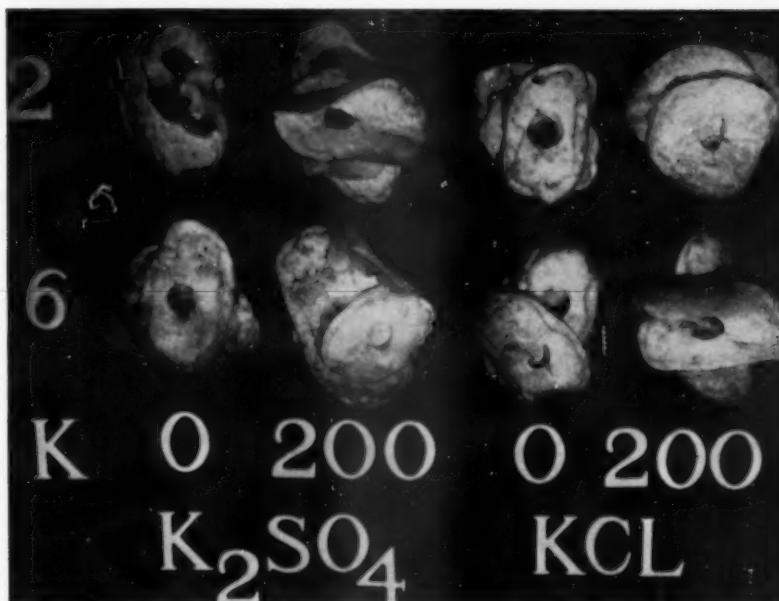


FIG. 1.—Potato chips made (top) two days after harvest and (bottom) six days after harvest from tubers that received sulfate and chloride treatments.

for the potassium treatments of 75, 150 and 225 pounds from June 1 to July 6. The zero potassium treatment tested 1,000-2,000 ppm. On July 14, the potatoes that had received no potassium fertilizer tested less than 1,000 ppm, the 75 pound treatment tested 2,000 ppm, the 150 pound treatment tested 3,000 ppm, and the 225 pound treatment tested 3,000 ppm. For a vegetable crop such as potatoes the greatest demand for nutrients is during the time of very rapid tuber development and a seemingly adequate nutrient level prior to this period of heavy demand can suddenly limit the plant's capacity to produce maximum yield and possible quality.

SUMMARY

The growth of potatoes was studied when grown with different rates of potassium, as sulfate and chloride fertilizer applied broadcast at planting time.

Tissue samples at prebloom stage showed no difference in P composition due to treatment in 1959 and 1960. However, samples collected at time of tuber development in 1960 showed reduction of P concentration as K fertilizer rate increased. Per cent K was increased in the tissue and Ca and Mg was decreased by increased K fertilizer rates. Only per cent Ca and Mg was affected by anion source of fertilizer and were higher on the Cl fertilizer treatments.

In 1960, potato yields were increased by K fertilization. Specific gravity was lower on the Cl treatments. Chip color was very dark for the zero potassium treatments, while higher rates of K resulted in lighter color chips. The high KCl treatment produced the lightest colored and most acceptable potato chips.

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POTATO VARIETY TRIALS (ALABAMA)¹CHARLES E. CUNNINGHAM AND FREDERICK J. STEVENSON²

Red Dot Foods, Inc. grows about 2,500 acres of potatoes on its farms in Wisconsin and Alabama. The potatoes produced supply about 40 per cent of the annual requirements of the various chip factories owned and operated by the company.

The present paper is a report of the variety trials in Alabama. Russet Sebago is the variety that, for some time, has been grown successfully on the Red Dot Farms near Mobile, Alabama. This variety produces relatively high yields. It possesses resistance to mild mosaic, late blight and brown rot. If its tubers are properly handled, and chipped on arrival from the harvest field high quality chips usually result. However, it is a late maturing variety and if permitted to grow even to partial maturity grass and weeds become a major problem interfering with harvest operations. Its tubers have a tendency to cling to the vines and too often are low in percentage solids. It is susceptible to heat necrosis and black leg. One of the objectives of the Research Program is to breed one or more varieties of potato that will replace, at least in part, the Russet Sebago on the company farms in Alabama.

MATERIALS AND METHODS

On the Red Dot Farms near Mobile, Alabama seedling varieties that have shown promise in the trials at Rhinelander, Wisconsin are tested in comparison with Russet Sebago and other standard varieties. From 30 to 40 sorts are grown annually in replicated tests. All seed is cut and suberized at Rhinelander³ before it is sent to Alabama for planting. All plots are planted early in February. In addition to the replicated tests from 100 to 300 seedling varieties are grown in 5-hill rows for observation.

At harvest time, notes are taken on season of maturity, tuber shape, and weight of potatoes of the varieties in the replicated plots and on maturity, tuber shape, and estimated yielding ability of the varieties in the observation plots. Tuber samples from all plots are shipped to Madison where specific gravity and chip color are determined.

VARIETY TESTS 1958

In 1958, twenty-nine varieties of potato were tested for yield and other characters in Alabama.

The seed pieces were cut and suberized in Madison before they were sent to Alabama. The varieties were planted in 25-hill rows, three feet between rows and one foot apart in the rows. All varieties were grown in four randomized blocks. Fertilizer with the formula 4-10-7 was applied at the rate of 2,500 pounds per acre. The plots were planted February 3, and harvested May 26.

¹Accepted for publication October 10, 1960.

²Geneticist and Director of Research, respectively, Research Department, Red Dot Foods, Inc., Madison, Wisconsin.

³In 1958 the seed potatoes were cut and the seed pieces suberized in the greenhouse at Madison.

Data for maturity, percentage solids, yield of potatoes, yield of dry matter per acre and chip color are given in Table 1.

Maturity — Seven varieties, Red Dot numbers 1, 6, 7, and 12, B926-9, B929-23 and Earlaime showed signs of maturity on May 7. Early Ohio and 13 other varieties were medium in maturity, distinctly

*Percentage solids*⁴ — The tubers of three varieties, Early Ohio, Iowa 8140-1 and Keswick were significantly higher in percentage solids than Russet Sebago, 18 were in the same class and the other 7 were lower in solids than the check variety.

Yield per acre — The yields were excellent. Russet Sebago produced 311 cwt. per acre. Three others, Red Dot 1, Red Dot 7, and B929-23 were in the same class in yield as Russet Sebago. These 3 varieties were early in maturity which gave them an advantage over the standard variety.

Yield dry matter per acre — B929-23, Russet Sebago, Red Dot 1 and Red Dot 7 yielded more than 5,000 pounds of dry matter per acre.

Chip color — Statistically there were highly significant differences in chip color among the varieties. However, only Manota and B69-16, scored below eighty which is the lowest score considered commercially acceptable. It is evident that many varieties grown on the Red Dot Farms in Alabama produce chips with high quality if the potatoes are handled properly and the chips fried soon after harvest.

OBSERVATION PLOTS 1958

In 1958, 107 seedling varieties of potato were planted for observation in Alabama. Each variety was planted in a 5-hill row.

Maturity — About 50% of the selections were scored extra early or early on May 7, earlier than, or as early as Red Dot 7. Forty five were medium early or similar to Plymouth, and 5 were late comparable in maturity with Russet Sebago.

Yield — Seven of the early varieties were better than the average in yield. The yields of 24 other earlies were about average. Some of the medium early varieties were superior in yield.

Tubers — The tubers of nearly all varieties tested had smooth shape and shallow eyes. The size of tubers of most selections was average or above. They ranged in percentage solids from 13.9 to 20.3 with an average of 17.0. The average of Russet Sebago grown under comparable conditions was 17.6%. Thirty-one of the seedling varieties were higher in percentage solids than Russet Sebago.

Chip color — The chip color of the 107 varieties ranged from 75 - 90 with an average of 85. Only 12 of them scored below 80 and 70 of them ranged from 85 to 90.

EARLY VARIETIES 1959

Eighteen early or medium early seedling varieties were planted in Alabama February 18, 1959. Early Ohio, Kennebec, Plymouth and Russet

⁴Percentage total solids determined by dividing weight in air by weight in air less weight in water and converting according to Maercker's chart.

TABLE 1. *Potato variety tests, 1958.*

Variety	Maturity ¹	Solids %	Yield per acre Cwt.	Dry matter per acre Lbs.	Chip color index ²
Earlaine	E	16.1	261	4202	85
Early Ohio	M	18.7	235	4395	86
Ia. 8140-1	L	18.8	258	4850	84
Kennebec	L	17.9	266	4761	88
Keswick	L	18.9	235	4442	83
Manota	L	17.4	229	3985	79
Mohawk	M	17.3	207	3581	87
Osseo	M	17.4	228	3967	84
Plymouth	M	16.4	255	4182	86
Pungo	M	17.2	273	4696	88
Red Dot 1	E	17.5	299	5233	86
Red Dot 2	M	17.9	250	4475	90
Red Dot 3	M	18.2	225	4095	88
Red Dot 4	M	16.3	265	4320	87
Red Dot 5	M	17.0	266	4522	88
Red Dot 6	E	17.4	251	4367	88
Red Dot 7	E	17.3	290	5017	90
Red Dot 11	L	16.4	216	3542	89
Red Dot 12	E	16.9	146	2467	87
Red Dot 13	L	18.3	252	4612	82
Russet Sebago	L	17.6	311	5474	88
Tawa	M	17.4	227	3950	88
B69-16	L	16.8	259	4351	79
B926-9	E	16.0	262	4192	86
B929-23	E	18.4	300	5520	87
B3408-1	M	16.4	267	4379	81
B3472-25	M	18.2	255	4641	90
B3584-5	M	16.6	197	3270	87
B3604-17	M	17.3	216	3737	88
LSD 5%		0.9	25		3

¹Maturity notes taken May 7.

E = early—similar to Earlaine

M = medium—similar to Early Ohio

L = late—similar to Russet Sebago

²Chips with a color index of 80 or higher are commercially acceptable.

Sebago were included for comparisons. The 22 varieties were planted in 4 randomized blocks. The plots consisted of two 20-hill rows. Two replications were harvested on May 26 and the other two on June 17. The data for these tests are given in Table 2.

Solids — On May 26 the 22 varieties ranged in solids from 15.5% to 19.5% with an average of 17.1%. On June 17 the solids ranged from 14.7% to 18.4% with a mean of 16.4% or a decrease of about 4% on a dry matter basis. Russet Sebago was below average on both harvest dates. This drop in dry matter is contrary to what might be expected since potatoes usually increase in percentage solids as the plants approach maturity. Rain and hot temperatures during the 3 weeks between harvests were no doubt responsible for the reduction in solids.

Yields — On May 26, Russet Sebago, Red Dot 21 and Plymouth were significantly higher in yield than the other varieties. On June 17

TABLE 2.—*Early and medium early potato variety tests,¹ 1959.*

Variety	Solids		Yield		Dry Matter		Chip color	
	May 26 Pct.	June 17 Pct.	per acre May 26 Cwt.	per acre June 17 Cwt.	per acre May 26 Lbs.	per acre June 17 Lbs.	May 26 index ²	June 17 index ²
Early Ohio	18.2	18.4	178	174	3240	3202	85	83
Kennebec	17.3	16.4	182	222	3149	3641	85	84
Plymouth	16.1	15.3	214	225	3445	3443	84	87
Red Dot 1	17.7	17.0	176	194	3115	3298	83	79
Red Dot 4	17.2	15.8	166	199	2855	3144	86	83
Red Dot 6	18.3	17.9	175	196	3202	3508	82	78
Red Dot 21	16.4	15.8	237	244	3887	3855	87	83
Red Dot 24	17.6	18.3	125	112	2200	2050	83	83
Russet Sebago	16.1	15.2	211	251	3397	3815	87	86
B926-9	16.2	15.3	149	168	2414	2570	85	85
B929-23	17.2	15.9	173	212	2976	3371	85	82
B3641-1	15.5	14.8	159	140	2465	2072	79	78
B4082-8	15.6	15.1	140	168	2184	2537	88	85
B4085-19	16.1	15.9	171	196	2753	3038	89	85
B4097-20	18.2	17.5	171	158	3112	2765	82	85
B4102-18	16.5	14.7	157	203	2591	2984	87	82
B4103-13	17.9	16.9	126	139	2255	2349	87	89
B4144-4	16.8	17.0	116	127	1949	2159	80	79
B4144-6	17.4	17.5	130	137	2262	2398	80	83
B4144-10	18.1	17.0	69	84	1249	1478	84	90
B4156-1	19.5	17.7	112	114	2184	2018	85	82
B4160-11	16.8	15.7	121	117	2033	1837	75	75
LSD 5%			27	40				
Mean	17.1	16.4	157	172	2678	2795	84	83

¹Planted February 18 in 4 replications. Two replications harvested May 26, the other two June 17.

²Chips with a color index of 80 or higher are commercially acceptable.

Russet Sebago, Red Dot 21, Plymouth, Kennebec and B929-23 were higher in yield than the other 17 varieties. On the first harvest date the average yield for the 22 varieties was 157, on the second date it had increased to 172 cwt. per acre or about 10%.

Dry matter per acre — During the time between harvests most of the varieties increased in yield of potatoes per acre but some varieties were lower in calculated dry matter per acre at the time of the late harvest than they were 3 weeks earlier.

Chip color — The color of the chips made from the early harvested potatoes ranged from 75 to 89 with a mean of 84, the color range for the late harvest was 75 to 90 with an average of 83. The chips from 20 varieties at the first harvest and from 17 at the late harvest were good to excellent in color.

LATE VARIETIES 1959

Twenty-seven varieties of potato were included in the late variety tests in Alabama in 1959. The design and procedures were the same as those used for the early and medium early variety tests. The data for the late variety tests are given in Table 3.

Solids — On May 26 the 27 varieties ranged in percentage solids from 15.3% to 19.6% with a mean of 17.3%. Russet Sebago was again below the average. On June 17 the range was 14.2% to 17.9% with an average of 16.4% or a decrease of about 5% on a dry matter basis. All varieties, with one exception were lower in percentage solids on June 17 than they were 3 weeks earlier. Contrary again to the general rule that dry matter content of potatoes increases as the plants mature.

Yields — On May 26, none of the varieties outyielded Russet Sebago significantly but 8 including Red Dot 20 were in the same class. On June 17, 5 varieties, among them Red Dot 7 and Red Dot 20, were in the same class in yield as Russet Sebago, but none was higher and the others were all lower. The mean yield for all varieties at the first harvest on May 26 was 168 cwt. per acre and 178 three weeks later.

Dry matter per acre — Although the yields of potatoes increased 6% on the average, the percentage solids decreased 5% with the result

TABLE 3. *Late potato variety tests¹, Mobile, Alabama 1959.*

Variety	Solids		Yield per acre		Dry Matter per acre		Chip color May 26 index ²	color June 17 index ²
	May 26 Pct.	June 17 Pct.	May 26 Cwt.	June 17 Cwt.	May 26 Lbs.	June 17 Lbs.		
Chippewa	15.3	14.2	206	211	3152	2996	83	74
Early Ohio	19.0	17.8	160	150	3040	2670	87	83
Kennebec	17.4	17.0	191	194	3323	3298	82	84
Marygold	18.5	17.5	203	204	3756	3570	78	82
Plymouth	16.6	15.2	190	209	3154	3177	82	80
Pungo	17.9	17.1	194	187	3473	3198	87	87
Red Dot 2	18.2	16.9	179	189	3258	3194	86	81
Red Dot 3	18.5	17.2	155	150	2868	2580	86	85
Red Dot 5	17.2	16.4	182	165	3130	2706	82	85
Red Dot 7	17.6	16.9	180	223	3168	3769	89	87
Red Dot 8	16.1	16.1	165	164	2657	2040	87	88
Red Dot 9	17.9	16.6	126	160	2255	2656	86	87
Red Dot 11	17.9	17.1	118	117	2112	2001	87	90
Red Dot 19	16.9	16.8	160	187	2704	3142	87	86
Red Dot 20	16.2	14.8	193	227	3127	3360	86	83
Russet Sebago	16.6	15.3	210	245	3486	3749	88	88
Saco	18.7	16.1	218	268	4077	4315	84	76
47156	19.6	17.9	151	196	2960	3508	79	82
B3404-11	17.1	14.8	113	93	1932	1590	87	89
B3428-31	15.7	15.0	126	126	1976	1890	86	83
B3444-25	16.2	16.0	133	127	2155	2032	83	83
B3472-25	17.5	16.8	136	140	2380	2352	86	82
B4082-3	16.3	15.2	181	179	2950	2721	80	78
B4134-9	17.0	16.4	154	147	2618	2411	80	78
B4144-2	18.3	16.9	196	198	3587	3346	80	79
B4156-4	17.3	16.8	149	155	2578	2604	82	81
B4160-9	16.3	15.0	154	185	2510	2775	74	81
LSD 5%			24	45				
Means	17.3	16.4	168	178	2903	2898	84	83

¹Planted February 18 in 4 replications. Two replications harvested May 26, the other two June 17.

²Chips with a color index of 80 or higher are commercially acceptable.

that the calculated mean weights of dry matter were on the average almost identical for both harvests. Eighteen varieties produced less dry matter per acre on June 17 than they did 3 weeks earlier. Saco ranked first in the production of dry matter per acre on both harvest dates with an average of 4228 pounds. Marygold was second with a mean of 3672 and Russet Sebago was third with a mean of 3648.

Chip color — The chips made from the tubers of the 27 varieties harvested May 26 ranged in color from 74 to 89 with an average of 84. Those from the June 17th harvest ranged from 74 to 90 with a mean of 83. On the first harvest date the chips made from 24 varieties scored 80 or higher in color. On the second harvest date the chips from 22 varieties scored 80 or higher.

OBSERVATION PLOTS 1959

In 1959, 178 seedling varieties were planted in 5-hill rows for observation. The plots were planted February 18 and harvested about June 17. Data were secured on vigor, vine character, size of tubers and potential yield. Samples were shipped to Madison where the specific gravity and chip color were determined. Twenty-eight of these varieties were selected to be included in the yield tests in Alabama in 1960. The plants of 17 varieties showed good vigor, 8 were above average in yield and 7 were above average in tuber size. Six of the selections excelled in all 3 categories, vigor, potential yield and size. The percentage solids of the 28 varieties selected ranged from 15.6 to 20.1 with an average of 16.9. They were all higher in solids than Russet Sebago harvested in a nearby plot on the same date. Red Dot 52-1 was the highest in solids, 20.1%. The chip color ranged from 80 to 89 averaging 85 and chips with good to excellent color were made from all 28 selections.

SUMMARY

In 1958, 29 varieties were grown in replicated yield tests and 107 in 5-hill plots for observation. Twenty-one varieties in the yield tests were earlier in maturity than Russet Sebago. Three varieties were higher in solids than the check. None outyielded Russet Sebago but 3 that were earlier in maturity were in the same class in yield. The chip color of twenty-seven varieties scored 80 or higher in color. The chip color of seventy of the varieties planted for observation ranged from 85 to 90 in color. In 1959 the yield tests were planted on February 18 in 4 randomized blocks. Two blocks were harvested May 26, and two on June 17. There were no significant differences in color of chips made from the tubers harvested on the two dates. The percentages of solids were lower on June 17 than they were three weeks earlier. Rain and hot temperatures in the interim increased yields but the dry matter content didn't keep pace. From the 178 seedling varieties planted for observation, 28 were selected for further tests. They were all higher in solids than Russet Sebago and chip color ranged from 80 to 89 with an average of 85.

EFFECT OF IRRADIATION ON STORAGE QUALITY
OF POTATOES¹R. L. SAWYER AND S. L. DALLYN²

INTRODUCTION

Sprouting of potatoes in storage has been the main factor determining length of storage life. All those who store potatoes including the processing industry and the Quartermaster Corps have considerable interest in sprout inhibition. Irradiation is one method of sprout control which has received considerable attention in recent years.

Since Sparrow and Christensen (12) in 1953 first observed that dosages of gamma irradiation controlled sprouting, many workers 1, 4, 7, 9, 10 have obtained evidence that irradiation was a very strong inhibitor. Sawyer et al (8) in 1955 indicated that irradiation caused an increase in susceptibility to black spot. Gustafson (3) observed that dosages over 15 kilorep caused increase in blackening, browning, fungus infection and respiration. Schreiber (9) found increased storage rots in irradiated tubers. Waggoner (13) observed that periderm formation was inhibited at dosages just above those necessary for sprout control although Isleib (6) indicated irradiation as low as 1500r prevented periderm formation.

Workers, in general, have reported complete sprout control at dosages of 5000 to 20,000r, depending on variety. Commercial control of sprouting may be obtained at somewhat lower levels. The present work, undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, was aimed at finding those levels of irradiation which would give satisfactory commercial control of sprouting without detrimental side effects such as rot, and the various darkening discolorations associated with the potato tuber.

MATERIALS AND METHODS

Gamma irradiation was done in the gamma field at Brookhaven National Laboratory. Dosages were obtained over a 40 hour treatment period with tubers rotated 180° at half-time. Fast electron irradiation was done at the High Voltage Engineering Corp., Cambridge, Mass. (2 million volt Van de Graff).

After irradiation, tubers were returned to the Research Farm and placed in storage. Shrinkage and sprouting data were taken after approximately 8 months in storage.

Black spot determinations were made after approximately 6 months storage at 40 F. each year. In the black spot program tubers were mechanically bruised in a tumbling machine which simulated normal

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handling in the commercial storage during removal and packaging of tubers. At least 48 hours from bruising, tubers were superficially peeled in an abrasive peeler and then hand trimmed to determine the extent of black spot. The black spot index took into consideration per cent of tubers showing black spot and severity of black spot. The index as described by Scudder (11) was derived from the formula:

$$\text{black spot index} = \frac{\% \text{ black} \times \text{severity reading.}}{10}$$

To determine the effect on after cooking darkening, tubers were held in storage for 8 months in 1955, 10 months in 1957 at 50 F. Tubers were peeled and placed in boiling water for 30 minutes and then left exposed to air for 30 minutes at 70 F. Samples were rated one through nine with one indicating no discoloration and nine severe discoloration.

Wound periderm formation and normal periderm formation were studied with Katahdin tubers from check and gamma irradiation treatment of 12,500r after storage at 50 F. for ten months. To determine wound periderm activity a strip of tuber surface was peeled at a uniform depth and the peeled area allowed to heal at 70 F. and 85% relative humidity for 10 days. Ten observations were made on each tuber sample. A one centimeter square portion of the peeled tuber surface was placed in a weak solution of Gentian Violet stain, sectioned with a freezing microtome, and mounted. This method did not involve any fixing or preservation since there was no delay between sampling and observation.

Varieties came from variety trials at the Long Island Vegetable Research Farm. The yearly factorial treatments were as follows.

1955. Experiment I

A. Irradiation (gamma)	B. Varieties	C. Storage temperatures
0	Cobbler	50 F
5,000	Katahdin	70 F
7,500	Green Mountain	
10,000	Kennebec	
12,500	Saco	

1955. Experiment II. Katahdin variety

A. Irradiation	B. Dosage	C. Storage temperature
1. Gamma	0	50 F
2. Fast Electron	10,000	
	20,000	
	40,000	
	80,000	

A. Irradiation (gamma)	B. Varieties	C. Storage temperature
0	Cobbler	50 F
5,000	Green Mountain	
7,500	Katahdin	
10,000	Russet Burbank	
12,500		

1957. A. Irradiation (gamma)	B. Varieties	C. Storage temperature
0	Katahdin	50 F
5,000	Green Mountain	
7,500	Kennebec	
10,000	Russet Burbank	
12,500		
15,000		

Randomized block design with a minimum of 4 replications was used in these factorially arranged experiments. Any differences discussed were statistically significant at the 5% level or greater.

RESULTS AND DISCUSSION

Sprouting, shrinkage and rot: Sprouting in Green Mountain and Katahdin was inhibited at lower dosages of irradiation than in other varieties tested. Dosages of 5,000 to 7,000r gave good commercial control with Green Mountain and Katahdin, whereas, considerable sprouting was still evidenced at 10,000r with Cobbler, Russet Burbank and Kennebec varieties. Fig. 1 contains sprouting results for 1955 and Table 1 shows the sprouting and shrinkage results for 1957. Similar variety dosage results were obtained in 1956. Rotting in the 1957 experiment varied from 13 to 15 tubers total in irradiation treatments at each dosage level, whereas, there was only one rotted tuber total from check treatments.

In the comparison of gamma and fast electron irradiation, similar results in sprouting and shrinkage were obtained with both types. Considerable more rot developed at dosages of 20,000r and higher than in check or 10,000r treatments. Sprouting was completely inhibited at 10,000r with both. Fig. 2 indicates the effect of the two types of irradiation on rotting when high dosages were used.

Black spot: Incidence was increased with both gamma and fast electron irradiation. In 1956, only the Katahdin variety showed any increase in black spot as affected by the irradiation dosage. These data are given in Fig. 3. The potato varieties differed considerably in susceptibility to black spot, induced by irradiation in 1957. These data are given in Table 2. The effect on Green Mountain was small and there was no effect on Russet Burbank. Marked responses were observed with Katahdin and Kennebec.

Over a period of 5 years, an increase in black spot due to irradiation at levels necessary for commercial control of sprouting was observed during one or more years with all varieties tested, except Russet Burbank. The two years data presented indicate the variability obtained. Kennebec variety has given an increase in black spot due to irradiation at dosages of 5,000r however sprouting was not controlled under dosages of over 10,000r. With Katahdin variety a dosage of 7,500r has given an increase in black spot while a dosage of over 7,500r has been necessary, at times, to give commercial control of sprouting. Both Pontiac and Ontario have exhibited increases in black spot due to irradiation at dosages as low as 5,000r (2). Commercial control of sprouting was designated at that level where sprouting would no longer seriously

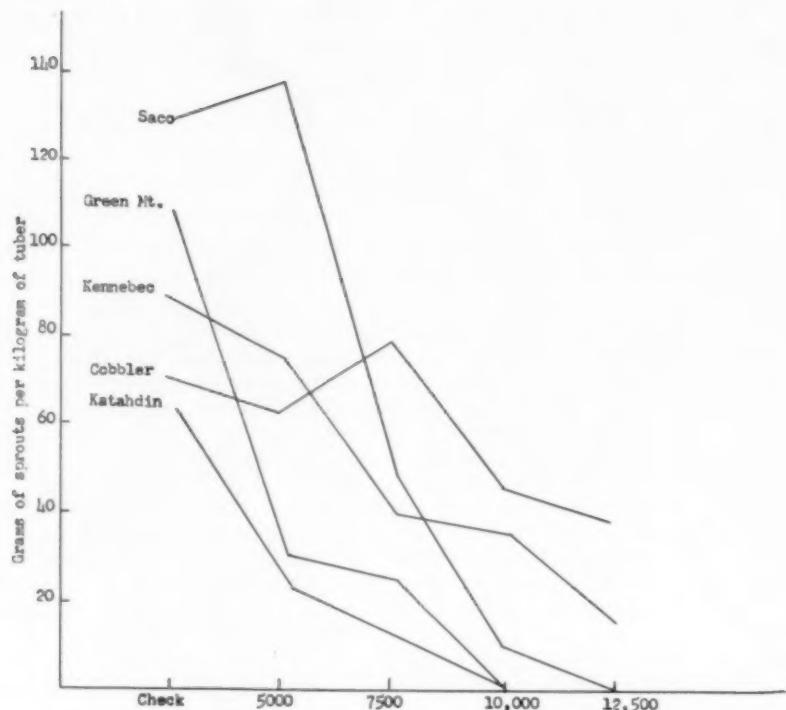


FIG. 1.—Variety-dosage interaction, grams of sprouts per kilogram of tubers, 50 F storage; 1955 results.

TABLE 1. *Sprouting and shrinkage of four potato varieties treated with gamma irradiation, 1957 results.*

Dosage	Katahdin		Green Mountain		Kennebec		Russet Burbank	
	Sprout. ¹	Shrink. ²	Sprout.	Shrink.	Sprout.	Shrink.	Sprout.	Shrink.
Check	31.4	10.0	120.4	8.8	38.3	12.2	62.0	12.8
5,000	10.6	7.5	32.5	13.4	30.5	12.2	37.2	12.8
7,500	2.5	9.9	13.6	10.5	26.2	12.2	35.1	10.0
10,000 .....	.8	8.2	3.2	10.8	10.5	11.8	22.8	8.1
12,500 .....	.5	4.4	0.0	9.1	3.5	12.0	6.0	6.1
15,000 .....	.1	6.8	0.0	8.3	.6	9.9	.1	5.4

¹Sprouting given in grams of sprouts per kilogram of tuber.

²Shrinkage given in per cent.



FIG. 2.—Effect of irradiation on rotting; left, gamma irradiation at 40,000 rep; center, check; right, fast electron irradiation at 40,000 rep.

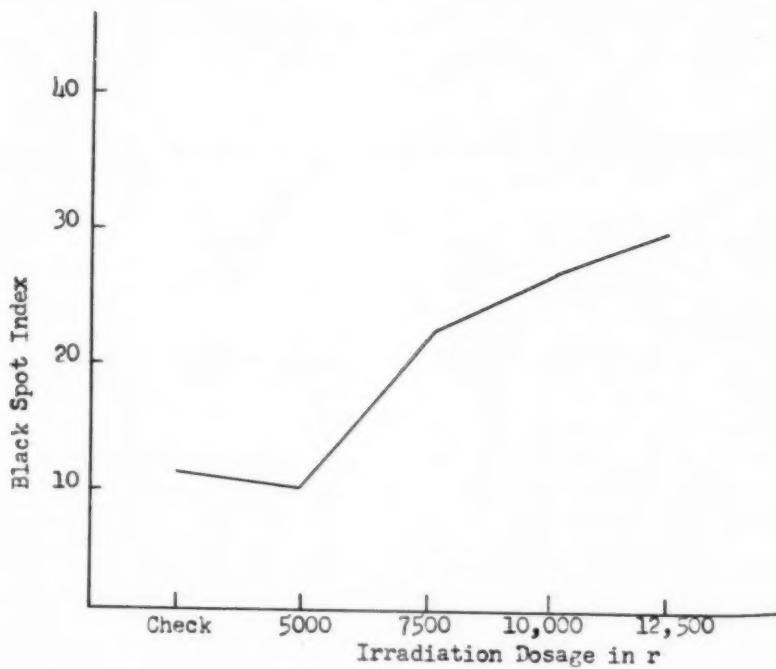


FIG. 3.—Effect of irradiation on black spot with Katahdin tubers; 1956 results.

TABLE 2. *The effect of gamma irradiation on black spot index¹ with Katahdin, Green Mountain, Kennebec and Russet Burbank, 1957 results.*

Dosage	Katahdin	Green Mountain	Kennebec	Russet Burbank
0	44.8	40.2	12.0	13.4
5,000	34.3	59.3	48.9	8.6
7,500	31.6	40.0	35.1	8.0
10,000	37.6	33.5	44.5	16.3
12,500	50.5	53.2	58.1	12.6
15,000	75.0	54.2	67.1	9.8

¹Black spot index = $\frac{\% \text{ black spot} \times \text{severity reading}}{10}$

affect the eye appeal for the consumer. Lower levels of irradiation than that necessary to give commercial control, for eye appeal, would keep down most of the weight loss due to sprouting.

After cooking darkening increased as the irradiation dosage increased. This was observed with gamma and fast electron irradiation. The 1955 data given in Table 3 indicate that irradiation dosages of 10,000 and 12,500r gave more after cooking darkening with all four varieties than checks or lighter dosages. The 1957 data given in Fig. 4 indicate increased after cooking darkening as the dosage was increased from 5,000 to 15,000r with all the varieties tested. Green Mountain had a high initial level in the check and darkening increased slowly as irradiation was increased in comparison to the other varieties tested. Considerable yearly variability was observed. The effect of irradiation on after cooking darkening with Katahdins is indicated in Fig. 5.

Suberization: Tubers still produced wound periderm after 10 months storage following treatment of 12,500r gamma irradiation. However, there was a reduction in wound periderm formation due to irradiation. There was a small reduction in normal periderm formation due to irradiation during the ten month storage period. This reduction was approximately 2 layers of cells, 20 microns in depth. The effect of irradiation on wound periderm formation is indicated in Table 4.

SUMMARY

Irradiation continues to be one of the strongest sprout inhibitors available, however, the following points must be given serious consideration if the potency of sprout inhibition is to be utilized.

1—Commercial control of sprouting, for long terms, can be obtained with most important potato varieties with irradiation dosages of 7,500 to 12,500r depending on the variety. There is considerable variation among varieties.

2—Storage rots can be increased by irradiation. Usually this is not encountered at the levels of irradiation necessary for commercial control of sprouting.

TABLE 3. *Effects of irradiation on after cooking darkening of four potato varieties, 1955 results.*

Dosage	Cobbler	Green Mountain	Katahdin	Russet Burbank
Check	2.0	3.5	3.0	2.5
5,000	2.0	2.5	1.5	1.0
7,500	5.5	2.0	3.5	2.0
10,000	6.5	3.5	5.5	3.0
12,500	6.5	6.5	7.0	4.5

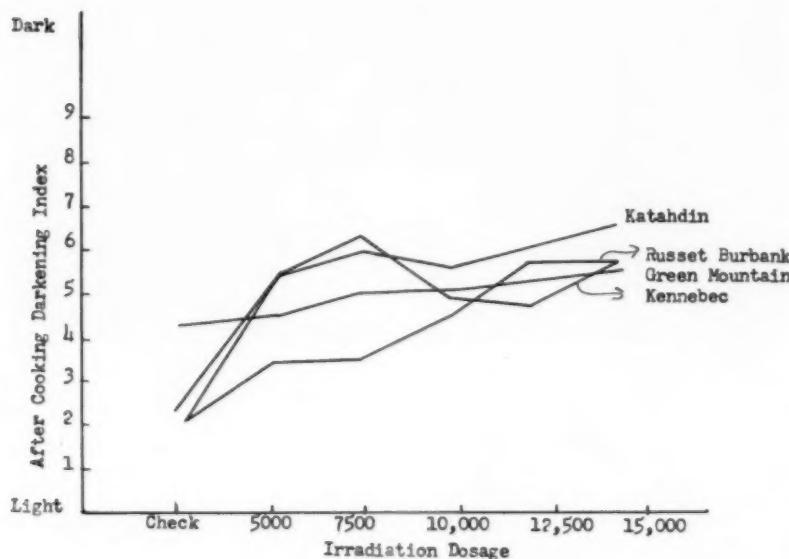


FIG. 4.—Effect of irradiation on after cooking darkening with four potato varieties; 1957 results.

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TABLE 4. *Effect of irradiation on wound periderm formation after 4, 8 and 10 day healing periods.*

	Days from wounding	Depth in microns suberized layer	No. of cells in wound periderm
12,500r	4	212	3.5
Check	4	233	3.4
12,500r	8	261	5.6
Check	8	379	7.6
12,500r	10	223	5.0
Check	10	434	9.0

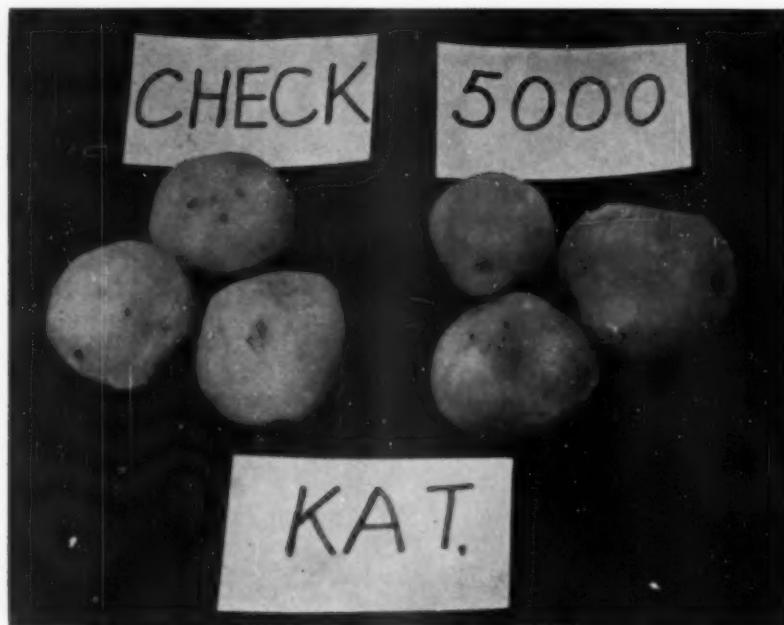


FIG. 5.—Effect of irradiation on after cooking darkening of Katahdin tubers; left, check; right, 5000 rep gamma irradiation; 1955 results.

3—Black spot of potatoes was increased by irradiation at levels necessary for commercial control of sprouting with most of the varieties tested.

4—After cooking darkening of potatoes was increased by irradiation at levels necessary for commercial control of sprouting with most varieties tested.

5—Irradiation at 12,500r caused a reduction in both normal and wound periderm formation.

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NAVAJO AND BLANCA: TWO NEW POTATO VARIETIES
RESISTANT TO SCAB AND ADAPTED TO COLORADO¹

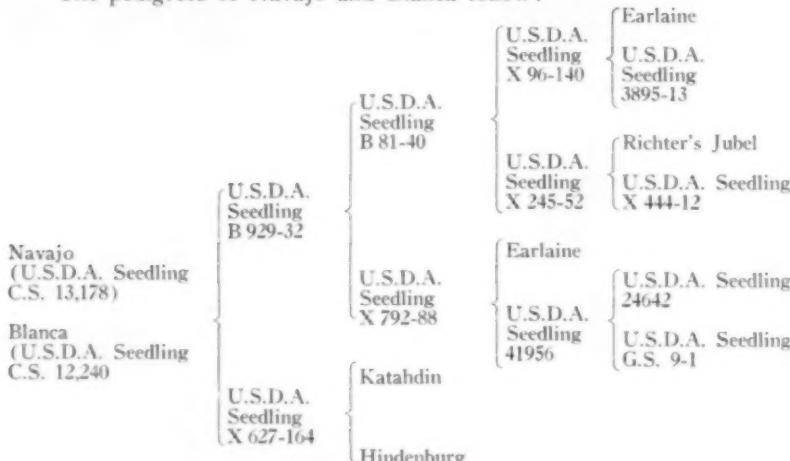
W. C. EDMUNDSON,² J. G. MCLEAN,³ C. W. FRUTCHEY,⁴
AND L. A. SCHALA²

On November 15, 1958 and April 27, 1959, the Crops Research Division of the United States Department of Agriculture and the Agricultural Experiment Station of Colorado State University released two new potato varieties Navajo and Blanca which were tested jointly by these two agencies.

Navajo and Blanca are sibs tested under pedigree numbers C. S. 13,178 and C. S. 12,240, respectively. They originated from a cross between U.S.D.A. seedlings X 627-164 and B 929-32. Both parents are medium in maturity and resistant to common scab of the potato. Seedling B 929-32 is also immune from the common races of the late blight fungus and from virus A in the field.

The original cross was made in 1951. Seedlings C. S. 13,178 and C. S. 12,240 were grown and selected the following year. Over a period of years subsequent tests made for yielding ability, scab resistance, and cooking qualities in Colorado indicated the desirability of releasing these varieties to commercial growers.

The pedigrees of Navajo and Blanca follow:



¹Accepted for publication January 16, 1961. Navajo named after the Navajo Indians of Western and Southwestern Colorado. Blanca named after Mt. Blanca, the predominant mountain peak of the San Luis Valley of Colorado.

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DESCRIPTION OF NAVAJO

PLANTS. Medium in size, erect to moderately erect. *Stems*: Medium thick, moderately angled. *Nodes*: Slightly swollen, green. *Internodes*: Green. *Wings*: Moderately prominent, straight, single, green. *Stipules*: Of leaves—Small, green, scantily pubescent. *Leaves*: Medium-sized, open, green. *Midribs*: Green, scantily pubescent. *Petioles*: Green, scantily pubescent. *Terminal leaflets*: Medium-sized, broadly ovate, acute, slightly lobed at base. *Primary leaflets*: Medium-sized, broadly ovate, 3 pairs, mean length 58.9 ± 0.9 mm, mean width 38.3 ± 0.7 mm, index 65.8 ± 0.7 .⁵ *Petiolules*: Green. *Secondary leaflets*: Few, between primary leaflets. *Tertiary leaflets*: Few. *Inflorescence*: Medium-branched. *Leafy bracts*: Few. *Peduncles*: On main stem, long, green, scantily pubescent. *Pedicels*: Medium in length, green, scantily pubescent.

FLOWERS. *Buds*: Much pigmented, calyx lobes medium in length (6-8 mm.), awl-shaped, not foliaceous, straight and green tips, scantily pubescent. *Corolla*: Medium-sized (27-33 mm.), color or flower fades (Maertz & Paul—Dictionary of color, McGraw Hill Co. First Edition 1930) Plate 41 fades from E5 through C5 through A3 to A2. From F6 "Daybreak" bud color to very nearly white in A2. *Anthers*: Orange-yellow. *Pollen*: Abundant, good quality. *Style*: Slightly curved. *Stigma*: Globose, slightly bilobed.

TUBERS. Nearly round, slightly flattened, mean length 85.7 ± 0.9 mm,⁶ mean width 75.8 ± 0.7 mm,⁶ mean thickness 58.1 ± 0.5 mm,⁶ indexes, width to length 91.4 ± 0.3 ,⁷ thickness to length 66.3 ± 0.5 .⁷ *Skin*: Smooth, light to medium-thick, white to light cream, waxy polish when buffed. *Eyes*: Shallow, same color as skin. *Eyebrows*: Medium, curved, not prominent. *Flesh*: White. *Sprouts*: Color when developed in dark, white. *Maturity*: Medium.

DESCRIPTION OF BLANCA

PLANTS. Medium in size, erect to moderately erect. *Stems*: Medium thick, moderately angled. *Nodes*: Slightly swollen, green. *Internodes*: Green. *Wings*: Moderately prominent, straight, single, green. *Stipules*: Of leaves—Small, green, scantily pubescent. *Leaves*: Medium-sized, open, green. *Midribs*: Green, scantily pubescent. *Petioles*: Green, scantily pubescent. *Terminal leaflets*: Medium-sized, broadly ovate, obtuse, at the apex, slightly lobed at base. *Primary leaflets*: Medium-sized, broadly ovate, 3 pairs, mean length 51.4 ± 0.9 mm, mean width 42.7 ± 0.9 mm, index 83.7 ± 1.0 .⁵ *Petiolules*: Green. *Secondary leaflets*: Few, between primary leaflets. *Tertiary leaflets*: Few. *Inflorescence*: Medium-branched. *Leafy bracts*: Few. *Peduncles*: On main stem, long, green, scantily pubescent. *Pedicels*: Medium in length, green, scantily pubescent.

⁵Calculated by dividing the width by the length of each 100 leaflets and multiplying by 100. The leaflets were taken from the fourth leaf from the top of the stem, one leaflet, the distal leaf lateral, being taken from each leaf. Since the potato leaflet is asymmetrical, the length was determined by taking the average of the measurements from the apex to the base of each respective lobe.

⁶Average measurements of 100 tubers, each weighing from 6 to 8 ounces.

⁷Calculated by dividing the width of each 100 tubers by the length and multiplying the average of these ratios by 100. The data used for calculating the indexes were taken from the same measurements as those used to designate the dimensions of the tubers.

FLOWERS. *Buds:* Green, calyx lobes long (8-10 mm), awl-shaped, not foliaceous, straight and green tips. *Corolla:* Medium-sized (25-31 mm). *Flower color:* Tips of petals are white in the bud stage. White color extends along midrib of petal on outside of flower to resemble a white indefinite stripe when flowers open. Outside edges of petals and inside of flower fades from Plate 42-E5 to Plate 42-C4 Maertz & Paul. Flowers when open resemble cyclamen (shooting star) with corolla curved back along pedicel. White stripes appear in center of petal on inner surface when flowers are old and faded. *Anthers:* Orange-yellow. *Pollen:* Abundant, good quality. *Styles* Straight to very slightly curved. *Stigma:* Rounded, very slightly trilobed, green.

TUBERS. Nearly round, slightly flattened, mean length 82.4 ± 0.9 mm (3.3 inches),⁶ mean width 71.2 ± 0.6 mm,⁶ mean thickness 53.2 ± 0.6 mm,⁶ indexes, width to length 87.9 ± 0.3 ,⁷ thickness to length 66.3 ± 0.4 .⁷ *Skin:* Generally slightly flaky to flaky, light to medium heavy, light cream to cream in color. *Eyes:* Shallow, same color as skin. *Eyebrows:* Medium, curved, not prominent. *Flesh:* White. *Sprouts:* Color when developed in dark, white. *Maturity:* Medium.

CHARACTERISTICS

Navajo and Blanca are varieties with smooth, white-skinned tubers that are oval to round and slightly flattened. Their plants are medium-maturing and medium in height. The results from field tests at 3 locations in Colorado for 2 years are presented in Tables 1 and 2.

The yields (Table 1) of Navajo and Blanca, when grown in the San Luis Valley and the Fort Collins trials in 1959, were low compared with those of Katahdin and Kennebec, but their percentage of U. S. No. 1 tubers and solids were similar to those of Katahdin and Kennebec.

In Table 2 are listed the percentages for yields, solids, second-growth and growth cracks, greening, and undersize and oversize tubers of Navajo and Blanca as compared with Russet Rural, Katahdin, and Kennebec when they were planted at 2 different dates and grown at Greeley, Colorado, in 1958. There were so significant differences in yields of U. S. No. 1 tubers between any 2 varieties. The average percentages of U. S. No. 1 tubers of Blanca and Kennebec were 80 and 69, respectively, compared with 91, 88, and 89% for Navajo, Russet Rural, and Katahdin.

The lowest percentage of solids for any variety was 20.2, which is very acceptable. Blanca with 9.2 and Kennebec with 9.5% of their tubers showing growth cracks and second-growth can be classified unusually high; Katahdin with 9.2 and Kennebec with 11.0% were high in tuber-greening from field exposure; Blanca with 7.5, Russet Rural with 5.9 and Kennebec with 7.1% were high in undersized tubers; and Katahdin was highest with 7.1% of oversized tubers.

The yields and solids of Navajo and Blanca compare favorably with those of the standard varieties grown in Colorado. Their solids content is usually higher than that of Katahdin. Both varieties have scab resistance. Navajo is moderately resistant to scab and may occasionally have enlarged pustules, but there are usually a smaller number of scab-infested tubers with fewer lesions than susceptible varieties. Blanca is highly resistant to scab and will produce scab-free tubers, where moderately resistant or susceptible

TABLE 1.—*Yields per acre and percentages of solids of Navajo and Blanca compared to those of 3 standard varieties grown at 2 locations in Colorado, 1959.*

Variety	San Luis Valley			Fort Collins		
	U. S. No. 1 tubers		Solids	U. S. No. 1 tubers		Solids
	Cwt.	Pct.	Pct.	Cwt.	Pct.	Pct.
Navajo	188	94	19.9	114	80	23.3
Blanca	230	94	20.0	163	75	21.8
Russet Rural ..	253	85	21.4	150	87	23.2
Katahdin	316	95	19.6	198	78	21.6
Kennebec	310	88	19.3	205	73	21.7
LSD at 5% ..	30					

TABLE 2.—*Yields per acre and percentages of solids, second-growth, greening, undersize and oversize tubers of Navajo and Blanca compared to those of 3 standard varieties planted at 2 different dates and grown at Greeley, Colorado, 1958.*

Variety	U. S. No. 1 Tubers			Tuber quality					
	Early ¹	Late	Mean	Solids	Cracks and 2nd-growth		Greening	Under-size	Over-size
					Cwt.	Pct.			
Navajo	271	92	297	90	284	91	20.5	1.9	3.3
Blanca	279	79	294	82	286	80	20.7	9.2	2.1
Russet									
Rural	192	86	201	92	197	89	21.8	3.6	1.1
Katahdin	301	87	322	89	311	88	20.2	1.9	6.7
Kennebec	189	67	209	71	199	69	20.4	9.5	11.0
LSD at 5% ..	NS	NS							

¹Early, planted May 5; Late, May 21.

varieties are badly scabbed. Navajo has shown some field resistance to early blight and some susceptibility to late infections of blackleg.

The cooking quality of Navajo and Blanca are good. Both varieties bake well. Navajo tends to slough when boiled too long, but this is not true of Blanca. The results of several years' testing showed that Navajo and Blanca tubers, when freshly harvested, and also when reconditioned after cold storage, were satisfactory for chipping. Their percentages of solids usually vary from 20.7 to 21.8 when grown in Colorado.

SUMMARY

Navajo (U.S.D.A. C.S. 13,178) and Blanca (U.S.D.A. C.S. 12,240) are high-yielding, medium-maturing, scab-resistant varieties adaptable to Colorado. Their tubers are smooth, white, and oval to round and slightly flattened. Tests have shown that they are equal to Katahdin in yielding ability and are usually superior in solids content. They are both good bakers. High-quality chips were made from their tubers after harvest and when reconditioned after storage.

WOUND BARRIER AND DECAY DEVELOPMENT OF POTATO SLICES AT 70 F. AS AFFECTED BY PREVIOUS TUBER STORAGE TEMPERATURES¹

W. L. SMITH, JR.²

INTRODUCTION

The effect of prolonged storage below 40 F on tuber quality has been noted by several investigators. Tubers stored at 32 F accumulate a high concentration of sugars and are unsatisfactory for processing (3, 7). Other work has shown that tubers from 32 F storage are more susceptible to bruising or cracking than tubers stored at approximately 50 F (6). Mahogany browning, particularly of the Katahdin and Chippewa varieties, occurs when tubers are held 20 weeks or longer at approximately 32 F (2,3). Seed pieces from tubers of some varieties stored at 32 F also have been shown to produce lower stands or yields than seed pieces from tubers stored up to 50 F (3,5).

Often, portions of potato storages may drop to approximately 32 F and remain at that temperature for several weeks. Aside from the development of mahogany browning, little is known about the effect of storage temperatures between 32 F and 40 F on spoilage of tubers at those temperatures and after they are transferred to higher temperatures. Studies were undertaken to determine the effect of different storage temperatures below 60 F on the development of decay of tubers at such temperatures and on vitality and decay development when slices from those tubers were placed at 70 F.

MATERIALS AND METHODS

Two varieties of potatoes were tested. Irish Cobbler tubers were placed at 32, 34, 40 and 55 F immediately after harvest. Katahdin tubers were stored at 50 F in addition to the above temperatures and were placed in storage approximately 1 month after harvest.

Sample tubers of Irish Cobbler were removed after 1 and 2 months' storage and of Katahdin after 1, 2 and 3 months' storage. At each examining period some of the tubers were washed and dried immediately on removal from storage, then 21 slices approximately 15 mm thick were cut and placed in moist chambers at 70 F. Other tubers were held 1 week at 70 F (reconditioned) before washing, drying, and cutting. Streptomycin sulfate 1000 ppm was added to all the moist chambers to reduce bacterial contamination on the bottom of the slices.

After 2, 4, and 7 days at 70 F, 7 slices were removed from the moist chambers. Three of these slices were used to determine the extent of wound barrier development. Sections approximately 20 μ thick were cut from the parenchyma region of each slice with a sliding microtome, stained, examined microscopically, and rated for wound barrier development in a manner previously described (5). The 4 slices remaining were

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The author appreciates the assistance of W. V. Audia and W. H. Miller in staining and rating the potato sections.

inoculated with a water suspension of cells of *Erwinia carotovora* (Jones) Holland washed from 24- to 48-hour agar slant cultures. The inoculated slices were returned to 70 F in moist chambers and rated after 48 hours for decay development.

RESULTS

Irish Cobbler

After 1 month's storage at 32 F the Irish Cobblers which were placed in storage immediately after harvest had severe shrinkage and pitting. Slices from these tubers developed slightly less suberin and periderm at 70 F and had a higher decay rating than slices from tubers held previously at 34, 40, or 55 F.

After 2 months' storage, pitted areas of the tubers at 32 F were severely infected with *Penicillium* sp. Generally, slices from these tubers developed less suberin and periderm and a higher decay rating than slices from tubers previously at higher temperatures (Table 1). Decay on slices of tubers from 34 F, 40 F, or 50 F was almost or completely eliminated by holding slices 4 days at 70 F previous to inoculation. After 7 days at 70 F, slices from the 32 F tubers were so badly infected with contaminating bacteria and fungi (mostly *Rhizopus* sp. and *Penicillium* sp.) that no sections or inoculations for decay reading could be made. Uninoculated slices from tubers at the other temperatures remained healthy during 7 days at 70 F.

Slices of reconditioned tubers from 32 F developed slightly more suberin and slightly less periderm at 70 F than slices cut from tubers immediately after storage. Slices of tubers from the other storage temperatures developed approximately the same amount of barriers as slices cut on removal from the various temperatures. Slices of reconditioned 32 F tubers were decayed by contaminants before they could be inoculated. Slices from reconditioned tubers from other temperatures usually devel-

TABLE 1.—Suberin, periderm and decay ratings¹ of Irish Cobbler potato slices at 70 F, as affected by 2 months' previous tuber storage at lower temperatures.

Time slices healed at 70 F and factors rated	Slice rating—2 months' tuber storage at			
	32 F	34 F	40 F	55 F
2 Days				
Suberin	0.8	2.1	1.8	2.4
Periderm	0	0	0	1.4
Decay ²	2.4	1.0	0.3	0
4 Days				
Suberin	1.8	4.8	4.9	4.0
Periderm	1.3	3.9	4.4	4.4
Decay ²	2.0	0	0.3	0

¹A rating of 0 = no wound barrier or decay. 5 = most wound barrier and 4 = complete decay.

²After 2 or 4 days healing at 70 F, slices were inoculated with *Erwinia carotovora*. Decay rated after 2 days incubation at 70 F.

oped more decay at 70 F than slices cut from tubers immediately after removal from the respective storage temperatures.

Katahdins

Katahdin tubers appeared normal after 1 month's storage at each of the temperatures. Previous holding temperatures of the tubers had little or no effect on suberin or wound periderm development at 70 F. More decay developed on slices from 32 F tubers inoculated after 2 or 4 days' healing than on slices from tubers stored at higher temperatures. No decay developed on slices inoculated after 7 days' healing.

After 2 months' storage, 32 F or 34 F tubers had severe pitting and shrinkage. Slices from 32 F tubers had approximately the same amount of suberin after 2 days' healing but less suberin and periderm after 4 days' healing than slices from tubers stored at the higher temperatures (Table 2). Slices from 34 F and 40 F tubers had more development of these barriers than slices from other tubers. More decay developed on slices from 32 F tubers inoculated after 2 days' healing than on slices of tubers from higher temperatures. After 4 days' healing, decay was reduced on all slices and eliminated after 7 days' holding.

After 3 months' storage, pitted areas in the 32 F or 34 F tubers were heavily infected with *Penicillium* sp. Most of these tubers also had mahogany browning. Slices from tubers stored at 32 F or 34 F developed approximately the same amount of suberin after 2 days at 70 F as slices from tubers at the 3 higher temperatures (Table 2). Decay developing on 32 F slices, however, was considerably greater. Within 4 days at 70 F all the remaining slices from 32 F and most of those from 34 F tubers were decayed by contaminating bacteria, *Penicillium* sp. and *Rhizopus* sp. These slices had a sour, disagreeable odor. Healthy areas in the slices from 34 F tubers after 4 days at 70 F formed more suberin than slices from the higher temperatures but periderm formation was less.

TABLE 2.—Suberin, periderm, and decay ratings¹ of Katahdin potato slices at 70 F as affected by previous tuber storage at lower temperatures.

Time slices healed at 70 F and factors rated	Slice rating—2 mo. tuber storage at					Slice rating—3 mo. tuber storage at				
	32 F	34 F	40 F	50 F	55 F	32 F	34 F	40 F	50 F	55 F
<i>2 Days</i>										
Suberin	1.8	2.3	2.1	1.7	1.1	1.6	1.4	1.4	1.1	1.1
Periderm	0	0.1	0.3	0	0.1	0	0	0	0	0
Decay ²	4.0	3.3	2.5	2.5	2.5	4.0	2.8	0.6	1.5	1.1
<i>4 Days</i>										
Suberin	1.9	3.8	3.2	2.3	2.2	.. ³	3.5	3.0	2.0	2.7
Periderm	1.6	2.7	2.9	2.5	1.9	.. ³	1.3	2.8	1.5	2.5
Decay ²	0.5	0.3	0.5	1.1	0.8	.. ³	.. ³	0	1.2	1.0

¹A rating of 0 = no wound barrier or decay. 5 = most wound barrier and 4 = complete decay.

²After 2 or 4 days healing at 70 F, slices were inoculated with *Erwinia carotovora*. Decay rated after 2 days incubation at 70 F.

³Slices entirely decomposed by contaminating organisms.

After 7 days at 70 F all the remaining slices from 34 F tubers were entirely decomposed by contaminating organisms. Slices from 40 F, 50 F and 55 F tubers had no visible growth or infection by contaminating organisms. When inoculated with *Erwinia carotovora* no decay developed.

After 1 and 2 months' storage, slices from the reconditioned Katahdin tubers from the respective temperatures formed wound barriers at approximately the same rate and had approximately the same percentage decay as slices cut from comparable tubers immediately on removal from storage. After 3 months' storage, almost all the reconditioned tubers from 32 F or 34 F had severely sunken spots covered with contaminating organisms, and internally had blackheart symptoms. Slices from these tubers formed suberin on the non-blackheart areas 2 days after cutting. Contaminating organisms covered the 32 F slices after 2 days and the 34 F slices after 4 days at 70 F. Slices from reconditioned tubers from the other storage temperatures formed approximately the same amount of suberin and periderm and had approximately the same percentage decay as slices cut from tubers immediately on removal from the respective storages.

DISCUSSION

Mahogany browning of Katahdin and Chippewa tubers is attributed to prolonged storage at low temperatures (2, 3). This symptom of low temperature damage does not appear in most of the other varieties. In these tests neither Katahdin nor Irish Cobbler tubers had internal symptoms of low temperature damage after 2 months' storage at 32 F or 34 F. Most of the Katahdin tubers had mahogany browning after 3 months' storage at those temperatures. Yet slices from Katahdin and Irish Cobbler tubers, after 2 months' storage at 32 F, did not form wound barriers as rapidly or extensively at 70 F as slices from tubers stored at higher temperatures. Decay of these slices also was greater than slices from tubers stored at higher temperatures.

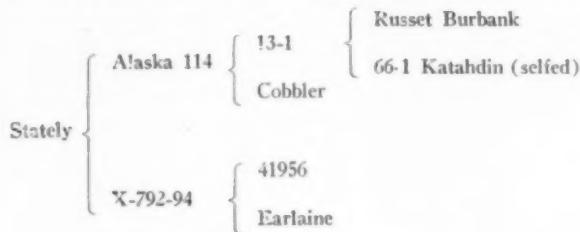
The symptomless low temperature injury reported in these studies therefore may at least in part explain high percentages of decay in some shipments of precut seed even though conditions favoring rapid development of wound barriers are provided.

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STATELY: A HIGH QUALITY HOME GARDENER'S POTATO FOR ALASKANS¹CURTIS H. DEARBORN²

Stately is a home gardener's potato for Alaskans who desire a potato that cooks white, fluffy and flavorful. It is a variety resulting from the cross of Alaska 114 by X-792-94. The selection was made in 1950 and tested under code A-43-10. Its pedigree is as shown:



DESCRIPTION

PLANTS: Medium, spreading irregularly. **Stems:** Medium thick, angled. **Nodes:** Smooth, green. **Internodes:** Green. **Wings:** Double, wavy, green. **Stipules:** Small, round, green, scantily pubescent. **Leaves:** Broad, wrinkled, open, dark green. **Midribs:** Green, distinctly pubescent. **Terminal leaflets:** Blunt, not lobed. **Primary leaflets:** Ovate, green, two pairs, medium with small third pair. **Petioles:** Green with slight purple pigment. **Tertiary leaflets:** Few, small. **Inflorescence:** Strong, branched. **Leafy bracts:** Common. **Peduncles:** Medium, pigmented purple, pubescent. **Pedicels:** Medium pigmented, pubescent.

FLOWERS: Bicolored, abundant, protruding well above foliage, general effect violet, corolla tips creamy white. **Calyx lobes:** Green, recurved, pubescent. **Anthers:** Yellow, plump, short. **Pollen:** Abundant, very good quality. **Style:** Medium long, straight. **Stigma:** Green, trifolobed. **Seedballs:** Many, large, green.

TUBERS: Elliptical to round, medium to small. **Mean length:** 69.8 ± 0.5 mm (2.7 in.). **Mean width:** 59.6 ± 0.4 mm (2.3 in.). **Mean thickness:** 46.5 ± 0.3 mm (1.8 in.). **Skin:** Slightly scurfy, white, tough. **Eyes:** Shallow, scarce. **Eyebrows:** Small. **Flesh:** White. **Sprouts:** White, basal portion pigmented when developed in the dark. **Maturity:** Late.

CHARACTERISTICS AND PRODUCTION OF STATELY

The tubers of Stately are nearly round, medium in size and white in color (Fig. 1). It is easy to prepare for cooking because the eyes are shallow and few in number. Stately develops the highest total solids, consistent with an acceptable tuber, of any seedling or variety bred or tested in Alaska.

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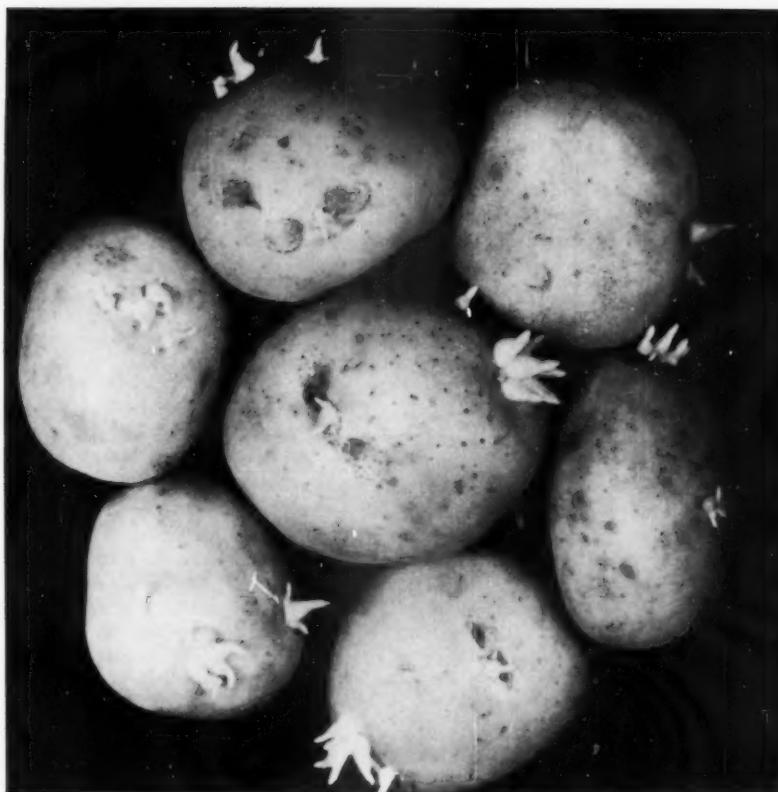


FIG. 1.—Stately potato showing general conformation of tubers. Excessive bud growth was permitted to illustrate position and number of eyes per tuber.

Stately was released so that Alaskans could have a high quality potato, even though its yield is significantly lower than standard varieties now being grown. Stately can be grown very successfully in the home garden. For home use, some yield can be sacrificed for high table quality. Many attempts have been made to grow imported russet varieties because these imported potatoes remain white after cooking and have a dry texture. Very low yields and tuber abnormalities such as second-growth, growth cracking and severe hollow heart have discouraged each venture. An important segment of Alaska's potato market is being filled by imported potatoes because of this preference for the dry-textured product.

Although Stately was released primarily as a home gardener's potato, some commercial growers who insist on careful handling of their crop may be able to grow this new variety economically. It meets many of the requirements of the restaurant trade and has the quality prized by tourists and others accustomed to the mealiness of out-of-state potatoes.

Stately has definite limitations for the commercial grower who produces for a quantity market. Its yield of tubers two inches in diameter and above is one third less than standard varieties. In cutting tubers for planting, the scarcity of eyes, as shown in Fig. 1, makes it impractical to cut the average tuber into more than three seed pieces. This apparent weakness is compensated for in part by spacing seed pieces further apart in the row, a necessary practice with Stately, a variety that develops many tubers per hill. Shatter cracking, a defect that occurs in the hill in some seasons, results in numerous growth cracked tubers at harvest. Shatter cracking that occurs at harvest can be serious to the commercial grower whereas the home gardener can postpone digging for a few hours or a day until the conditions favoring shattering have changed.

Stately has been grown in Southeastern Alaska and adjacent coastal islands, as well as in the valleys of the Matanuska, Susitna, Kuskokwim, Tanana and Yukon Rivers. Best yields have been obtained where ample water for growth has been provided.

With overhead irrigation at Matanuska Station, the yield of Stately was 22% higher than where grown without irrigation. Total solids content was not reduced significantly by irrigation although some lower quality varieties did show a reduction in total solids in the same test. Irrigation soon after emergence held growth cracking to a minimum.

Stately has shown remarkable storage qualities with a minimum development of storage rot. The sweet taste common to many potato varieties that have been tested in Alaska is slow to develop in Stately. After six months of storage at 38 F, a sample of Stately contained 45% less sucrose and 57% less reducing sugar than other potatoes. Vitamin C content of this sample was nearly double that of other potatoes stored and handled in the same manner as Stately. These characteristics are highly desirable.

In a cooperative study³ on newly cleared land, Stately was tested in 1953 for productivity and quality in comparison with 13 other varieties and seedlings. The object of the test was to learn if yields of Stately could be improved by applying fertilizer in bands, at planting, at the rate of 120 lb. of nitrogen, 360 lb. P₂O₅ and 80 lb. K₂O per acre. This rate was nearly double that recommended for potatoes in 1953.

The relative productivity and total solids of Stately and other leading varieties are shown in Table 1.

Yield of tubers over 1 $\frac{1}{2}$ inch diameter was approximately sixty per cent of that of leading varieties. Heavy fertilization did not increase the yield of Stately to the level of heavy producing varieties.³

Under the heading "per cent loss" the grade-out for Stately of 18% represents tubers that developed shatter cracks at harvest. This loss can be reduced to 5 or 6% by careful handling of the tubers throughout the harvest and storage operations. No special handling precautions were exercised in this case because the variety was so new that its peculiarities were not known. It is significant to note that high quality associated with 23.8% solids of Stately exceeded Green Mountain by 22%. Green Mountain has been the standard for high solids for many years. At

³The writer gratefully acknowledges the donation by potato grower Ted Knudson, Wasilla, Alaska, of land, facilities and time that made this experiment possible.

TABLE 1.—*Total and marketable yield, per cent grade out and total solids of leading varieties.*

Variety	Yield, cwt. per acre ¹		% Grade out	% Total solids
	Total	*Marketable		
Stately	77.2	63.5	18	23.8
Green Mountain	137.2	110.7	19	21.6
Alaska 114	105.8	102.2	3	21.5
Kennebec	128.2	109.7	14	20.0

¹Potatoes of 1½" minimum diameter.

the time of this study, yield in hundred weight per acre rather than total solids content determined whether a potato variety would be grown. In recent years, quality has been the important consideration.

Other studies have shown that a good yield of Stately can be obtained on most soils by supplying the crop with 80 lb of nitrogen, 320 lb of phosphorus as P_2O_5 and 160 lb of potassium as K_2O per acre. Where double this rate was applied in bands at planting, growth cracking was increased significantly without concomitant increase in yield. With the high rate of fertilizer a few of the tubers that were over 3½ inches in diameter developed hollow heart. Hollow heart is not normally present in Stately tubers.

COOKING QUALITIES

Stately is scored as excellent for mashed potatoes because of its fluffy consistency and whiteness. Freedom from darkening after cooking is one of its important attributes. In baking tests it has been necessary to puncture the skin of each tuber to release steam pressure, otherwise a tuber might explode in the oven while baking. After a period of storage, better potato chips were made from Stately than from other varieties treated similarly.

Stately is also very desirable when French fried. Generally the French fried product lacks uniformity of strip length because many pieces are necessarily short when cut from short thick tubers. Because this potato remains white after cooking, mashes to a light fluffy consistency and has an excellent flavor, airline chefs and restaurant trade may provide a ready outlet for the home gardener's surplus.

DISEASE SUSCEPTIBILITY

Scab is the only disease that has been observed on Stately. In all tests it has been as susceptible as Green Mountain. Eye canker, as shown on several tubers in the photograph, disfigures the eyebrow of some tubers, especially when the variety is planted in newly cleared land. Eye canker, although somewhat unsightly, does not affect the palatability or the storage life of the tubers.

Since late blight, *Phytophthora infestans*, is not present in Alaska, Stately's resistance to this disease is not known. Ring rot, *Corynebacterium sepedonicum*, has never been observed in a commercial planting of Stately; however, the variety has developed the disease after artificial inoculation and is therefore presumed to be susceptible.

SUMMARY

Stately, a new high quality potato, was selected and released to meet the standards that tourists and new settlers associate with some varieties of imported potatoes. Heretofore persons who chose to have this quality for their table had to rely on imports because no variety with the desired characteristics was available in Alaska that could be produced economically by Alaskan growers.

Stately does not yield so well as standard varieties now being produced commercially and therefore may remain a home gardener's variety. It seems likely that restaurants and discriminating caterers as well as airline chefs would use this variety to the exclusion of imported potatoes if Stately were produced in sufficient volume to provide them with a steady supply.

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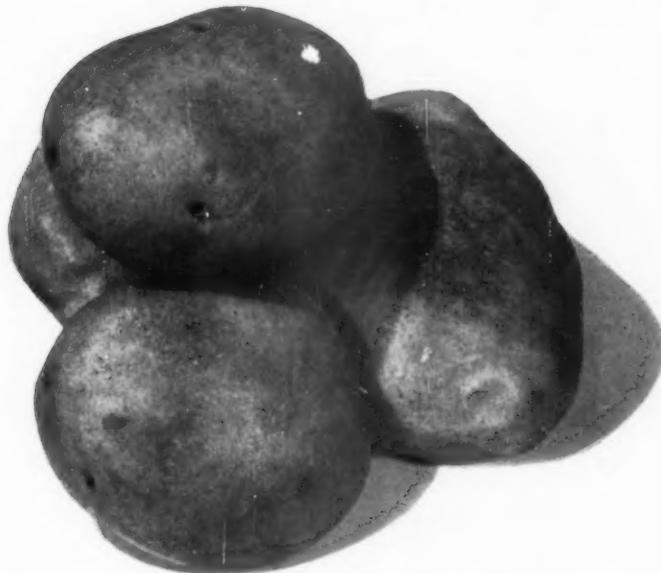
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